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East Europe Report

ECONOMIC AND INDUSTRIAL AFFAIRS

(FOUO 6/81)

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CZECHOSLOVAKIA

CONSERVATION EFFECTS ON ENERGY CONSUMPTION EVALUATED

Conservation--One of Main Goal-Oriented Programs

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[Article by Eng I. Kopernicky, Doctor of Natural Sciences, Candidate for Doctor of Sciences, technical secretary of the enterprise director of Slovnaft national enterprise: "Fuel and Energy Conservation--One of the Main Target Programs in Crude Oil Refineries"]

[Text] The world has serious energy difficulties. There is an imbalance between sources and needs. Fears are being expressed concerning the future development of the energy situation, its worldwide importance is being emphasized, and issues related to possible solutions are being pursued intensively. As a group of problems, energy receives immediate and concrete expression not only in connection with the macroeconomic issues of the world economy and the development of national economies, but is also beginning to reach the foundations of the economic considerations of every one of us.

In this article I want to point out the significance and importance of the rationalization of fuel and energy consumption, based on a brief overview of the status of energy reserves and the development of their worldwide consumption, and point out the results achieved by Slovnaft in this area. In conclusion, I will present some thoughts on the further development of the rationalization of fuel and energy consumption with a certain orientation toward oil refining.

One of the main phenomena in the development of human society in recent decades is the constant and sharp increase in the consumption of energy. The development of the world energy balance is a phenomenon which has a particular dynamic. Average yearly energy consumption at the beginning of the sixties was about 5 billion metric tons of standard fuel (7 X 10^6 kilocalories, 8,141 kilowatt hours), while at the beginning of the seventies it was about 7 billion metric tons of standard fuel with a trend toward constant yearly increases, so that the expectation was that by 1980 this consumption would be between 11 and 12 billion metric tons of standard fuel. World energy consumption has developed so rapidly that a doubling or tripling in its volume required thousands of years at the beginning of human history, while at the present time such increases occur every 20 years. It is also clear that energy consumption is developing more rapidly than world population. Between 1960 and 1970, the number of inhabitants increased 27 percent, while energy consumption increased 59 percent. According to the International Atomic Energy Agency (IAEA) this growth ratio should be 2.5 to 11 between 1950 and 2000 and Soviet estimates, which presume a quintupling of population over 100 years, predict a necessary increase in energy consumption of 20 to 40 times.

The increase in world energy consumption is influenced by the increased numbers of inhabitants near the equator, by the development of their personal consumption, the consequent increase in energy consumption per capita and, above all, economic development, in which transportation plays the dominant role from an energy viewpoint. Fully one-quarter of all consumed primary energy is expended at this time on the transportation of people and goods. The importance of energy consumption becomes clearly evident when we compare the average yearly increase in economic growth and in energy production for the most industrially developed regions of the world. (Table 1)

Table 1. Trends in Economic Development and Energy Production, 1960-1973

Area	Economic Development	Energy Production Increase
United States	4.0	4.1
Western Europe	4.8	4.8
Japan	10.2	11.2
USSR	7.0	5.3

The vital tie of an economy to energy is, however, most clearly shown through a comparison of economic growth and electrical energy consumption in average yearly increments. According to West German statistics, this ratio developed, in the mature and efficient West German economy, in such a way that from 1951-1960 an average economic growth rate of 8 percent was accompanied by an average yearly increase in electrical energy consumption of 10.3 percent, from 1961-1970 these figures were 4.7 and 7.3 percent, and from 1971-1977 2.5 percent and 5.3 percent, which represent coefficients of 1.29, 1.55, and 2.12.

Predictions for the development of energy consumption vary, but it is characteristic of all of them that the originally predicted growth rates have been reduced, due to conservation measures ("energy conservation program"). There is a 20 percent difference in the maximum and minimum estimates for the year 2000, which in absolute terms represents about 2,500 metric tons T.J. [terajoule] of standard fuel, i.e. about half of current consumption. Predictions such as those presented in Table 2 are concerned with the development of energy consumption in individual sectors. (See bibliography, citation 3).

Table 2. World Energy Consumption, by Sector (in percent)

Sector	1972	2000
Industry	37	42
Petrochemicals	7	10
Transportation	27	25
Households and Tertiary Sector	29	23
Total	100	100
Losses	43	42-48

Industrial consumption will increase at the expense of households and services, as well as transportation. This phenomenon is a consequence of the development of the "third world," which is based on industrialization. The share of the developing areas in the overall consumption of primary energy resources in the capitalist world will increase from 15 percent in 1975 to 25 percent in 2000. The amount of losses is open to discussion, and depends on the share of total consumption represented by electrical energy. This share is growing constantly, from 18.7 percent in 1960 to 25 percent in 1975, to a projected figure of 31.4 percent in 1980. Most predictions assume that this share will be in excess of 50 percent by 2000.

Table 3 presents the consumption of energy resources in millions of Mgmp of standard fuel according to the predictions of citation 3 in the bibliography.

Table 3. Energy Resource Consumption in Millions of Metric Tons of Standard Fuel [MTSF]

	1975		1985		2000	
Resource	MTSF	Percent	MTSF	Percent	MTSF	Percent
Crude Oil	3,307	55.0	4,687	50.9	6,945	46.8
Natural Gas	1,132	18.8	1,575	17.1	2,077	14.0
Coal	1,087	18.1	1,447	15.7	2,542	17.1
Nuclear Energy	52	1.0	900	9.8	2,107	14.1
Water	427	7.1	585	6.4	870	5.7
Other	7	-	4	-	377	-
Total	6,012	100	9,198	100	14,848	100

Other data on the future percentage of crude oil among primary energy sources predict that its share will decrease by 1985 to 44 percent and by 2000 to less than 40 percent, while natural gas will decline to 16.2 percent of the total by 1985 and to 12.7 percent by 2000. (See bibliography, citation 5).

In view of the high consumption of energy resources, fears have been expressed that their reserves, especially those of crude oil, will be soon exhausted and needs unable to be met. There have been many studies and much field prospecting undertaken in connection with this theme. And although individual data differ, there exists in this area general agreement which may be considered sufficient from an energy viewpoint. Table 4 presents the current situation for the main contemporary energy resources. (See bibliography citation 1)

Table 4.

Resource	Assumed Reserves in Billion MTSF	Extracted to Date (%)	Life of Reserves
Crude Oil	214	34	34
Black Coal	544	23	168
Natural Gas	119	19	65

According to other statistics related to the special life expectancy of reserves, world supplies of brown coal are sufficient for 100 years, crude oil (including oil shale and sands) for 80 years, and natural gas for 70 years. This data should be taken as a lower limit, because we are constantly discovering new reserves.

A problem related to energy resources is their territorial location on the earth in comparison with the energy consumption in the industrially developed regions. The main energy consumers are the economically developed regions. They account for an average of 80 percent of total energy consumption, and almost 90 percent of natural gas consumption, and their crude oil consumption also exceeds this aggregate figure. The extraction and reserves of the main energy resources are, however, located differently. Coal is distributed relatively adequately. Seventy percent of its mining is concentrated in the industrially developed countries, which approximately corresponds to the percentage of total reserves located in these areas. Developing regions mine about 5 percent of the black coal and 20 percent of the total brown coal. There is a different situation with natural gas. To be sure, the production from developing regions amounted to 12.5 percent of the total in 1977, but 43 percent of total reserves are located in these regions. And the structure of consumption and the territorial location of crude oil reserves is completely inadequate. In 1978, economically immature, undeveloped regions accounted for more than half of worldwide production. Their share of total reserves is still greater, in the vicinity of 75 percent. (See Table 5, bibliography citation 4).

Table 5. Overview of Major World Deposits (1975)

Region	Crude Oil: Number of Large Deposits	Crude Oil: Proven and Potential Reserves (10^6 barrels)*	Natural Gas: Number of Large Deposits	Natural Gas: Proven and Potential Reserves (10^6 barrels)*
USSR	37	103,009	61	188,716
United States	53	64,782	27	37,324
Canada	8	6,866	6	3,600
Latin America	34	59,396	7	4,234
North America	36	46,017	11	33,356
Europe (excluding USSR)	21	20,850	12	22,454
Middle East	88	515,148	51	148,463
Far East	17	16,485	15	15,569
China	5	3,528	2	1,800
Total	299	836,081	192	455,516
World Proven and Potential Reserves Total	1,105,000		520,604	
Percentage Contained in Large Deposits	76		87	

*Note: One barrel contains about 159 liters

It follows from these figures that the contemporary world, from the viewpoint of energy issues, does not represent a whole, the parts of which are balanced and the mutual interaction of which would lead to harmonized relations. This reality is the more valid when we study world energy issues as a comprehensive, i.e., socioeconomic phenomenon. The critical characteristic is that a minority of the world's population, concentrated in the economically developed regions, consumes the vast majority of the energy produced worldwide, at the same time that world energy resources are for the most part located in precisely the economically backward areas of the world, where most of the people live.

Table 6 presents the energy and crude-oil consumption per capita in certain areas. (See bibliography citation 6). From Table 6 it is evident that many economically developed capitalist regions, while having, for practical purposes, no domestic crude-oil resources, have been processing these resources for prices well below the actual value of the crude oil. Only the so-called energy crisis, which came about as a consequence of a sharp increase in crude-oil prices and their constant raising by the OPEC cartel, caused mankind to begin to seriously consider energy-resource issues in relation to its future development. We became aware that reserves of crude oil, natural gas, and coal are exhaustible, and that therefore it is necessary a) to search for replacement sources of energy; b) to utilize existing energy resources rationally.

Table 6. Energy and Crude Oil Consumption per Capita

	Energy Consumption (MTSF)				Crude Oil Consumption (kg)			
Region	1960	1965	1970	1975	1960	1965	1970	1975
Belgium	3,851	4,384	5,555	5,584	666	1,229	1,892	1,859
France	2,474	3,087	3,956	4,944	500	935	1,595	1,652
Italy	1,086	1,752	2,793	3,012	375	790	1,375	1,411
West Germany	3,695	4,736	5,419	5,345	504	1,140	1,829	1,741
Holland	2,504	3,323	4,943	5,784	708	1,322	1,508	1,210
Austria	2,129	2,644	3,408	3,700	369	691	1,113	1,224
Great Britain	4,861	5,080	5,336	5,265	713	1,045	1,444	1,349
United States	8,172	9,176	11,020	10,999	2,262	[illegible]448	2,956	3,111
Hungary	2,072	2,812	3,152	3,624	173	317	528	831
Poland	3,107	3,514	4,269	5,007	68	129	215	338
East Germany	4,950	5,434	6,051	6,835	78	193	479	826
CSSR	4,741	5,720	6,522	7,151	123	344	575	934
World Total	1,423	1,587	1,902	2,028	294	385	528	579

Replacement Energy Resources

After exhausting the resources of fuels which are currently mined, or after the prohibition on the use of solid fuels (this eventuality is being considered as a consequence of an increase in the CO_2 content in the atmosphere, and the resulting greenhouse effect), it will be necessary to assure a yearly supply of 2×10^{18} kilojoules of energy.

There exist two basic possibilities: the use of nuclear energy, and the use of solar energy and other nontraditional resources.

At the same time it is necessary to take into consideration the temperature level of thermal energy and the need for mechanical and electrical energy.

The use of atomic energy as one of these energy sources belongs among the fundamental paths to a resolution of the energy problem. The construction of atomic power plants is proceeding more rapidly throughout the world even while, for the time being, there are differing positions in individual regions regarding the building of such power plants. This is connected with problems of safety and reliability in the operation of atomic power plants, problems in the protection of the environment, as well as the production of raw materials for the production of atomic weapons (plutonium). It is a task for science and technology to resolve the problems connected with the more extensive use of atomic energy and to more fully master thermonuclear reactions.

At present there exist about 240 atomic power plants worldwide with an installed capacity of about 120,000 megawatts. An almost equal number are under construction, and 120 are still in the planning stages. By the beginning of the nineties there should be 600 power plants in the world with a capacity of 440,000 megawatts. In 1979, the CEMA countries had an installed capacity of 15,000 megawatts. The construction of additional atomic power plants is part of the development plans for several CEMA countries. In the CSSR, we have an installed capacity of 880 megawatts, with 10 units of 440 megawatt contracted for (the first generation of reactors), which means that the total capacity of first-generation reactors will be 5,280 megawatts. By 1990 we should have a total atomic power plant capacity of 9,000 to 10,000 megawatts.

The Energy Situation in the CSSR

Table 7 shows the geological reserves of primary energy resources. This table shows that we are among the regions with developed industrial production, but which for practical purposes has no large primary energy resources at its disposal. For completeness I will note that the usable hydroelectric potential is roughly 9 billion kilowatt hours per year.

Table 7.

Type of Energy Resource	CSSR	World	Percent of World Reserves
Black Coal (10^6 megagrams [Mg])	11,573	8,129,968	0.142
Brown Coal (10^6 Mg)	9,857	2,623,916	0.376
Crude Oil (10^6 Mg)	1.7	91,525,000,000	-
Natural Gas (cubic kilometers)	15	52,532,000,000	-

Our consumption of primary energy resources has evolved as in Table 8.

Table 8. Composition of Primary Energy Resources (PEZ)

	1960	1965	1970	1975	1980	1985
Domestic Consumption of PEZ (million MTSF)	56.9	71.7	81.2	93.2	106.2	118.1
Imported PEZ (million MTSF)	6.7	14.6	22.8	34.5	44.7	47.5
Share of Imports in Coverage of PEZ Requirements (percent)	11.7	20.4	28.1	37.0	42.0	40.2
Share of Imports in Coverage of Increased Domestic Consumption (percent)	-	53.4	86.3	97.5	78.5	23.5

From this table, it is clear that while in the Fifth Five-Year Plan the whole increase in domestic consumption of fuel and energy resources was assured by increased imports, only 78 percent of this increase was so assured between 1976 and 1980 (22 percent of the increase was covered by the development of our own fuel and energy resources). This trend will be strengthened significantly in the next five-year plan, when out of an overall increase in domestic consumption of primary fuel and energy resources of about 12 million Mgmp of standard fuel, imports of enriched fuels will compose roughly 24 percent. For practical purposes, by the Seventh Five-Year Plan there will be a decline in the absolute volume of primary energy resources, at the same time that there will be an overall increase in their consumption. Crude oil and natural gas still predominate among imports and increases in their consumption will be practically totally covered by increased imports. (Table 9, bibliography citation 7).

Table 9. Evolution of Domestic Consumption of Crude Oil, Crude-Oil Products and Natural Gas

	1960	1965	1970	1975	1980	1985
Domestic consumption						
Total	5.4	9.5	17.0	27.9	38.0	42.7
Growth	-	4.1	7.5	10.9	10.1	4.7

With regard to the development of the situation in the assurance of fuel and energy on world markets, it is necessary to limit substantially the growth of imports of fuel and energy resources. This is mainly a question of crude oil, and due to limitations on its delivery from the USSR to 1980 levels, increased imports in the Seventh Five-Year Plan will have to be realized on capitalist markets to the extent of the capabilities of our economy. A comparison of the employment of particular fuels in domestic consumption in the years of the Seventh Five-Year Plan with that of the Sixth Five-Year Plan shows a significant increase in the production of electricity from atomic power plants, an approximately 25 percent increase in the growth rate of solid fuel consumption and a substantial restriction in increased crude oil and natural gas consumption. (Table 10, bibliography citation 7).

Table 10. Consumption Structure of Fuel and Energy Balance

	1970	1975	1980	1985
Total Domestic consumption	100	100	100	100
made up of:				
Solid fuels	75.3	66.5	40.7	57.0
Gaseous fuels	3.3	5.5	9.3	10.3-10.7
Liquid fuels	17.6	24.5	26.4	25.5-25.8
Other fuels and energy	3.8	3.6	3.6	6.8-6.9
Including:				
Electricity from atomic power plants	-	-	1.1	4.5

To form a conception of the overall fuel and energy balance of our national economy, I have compiled the diagram in Figure 1.

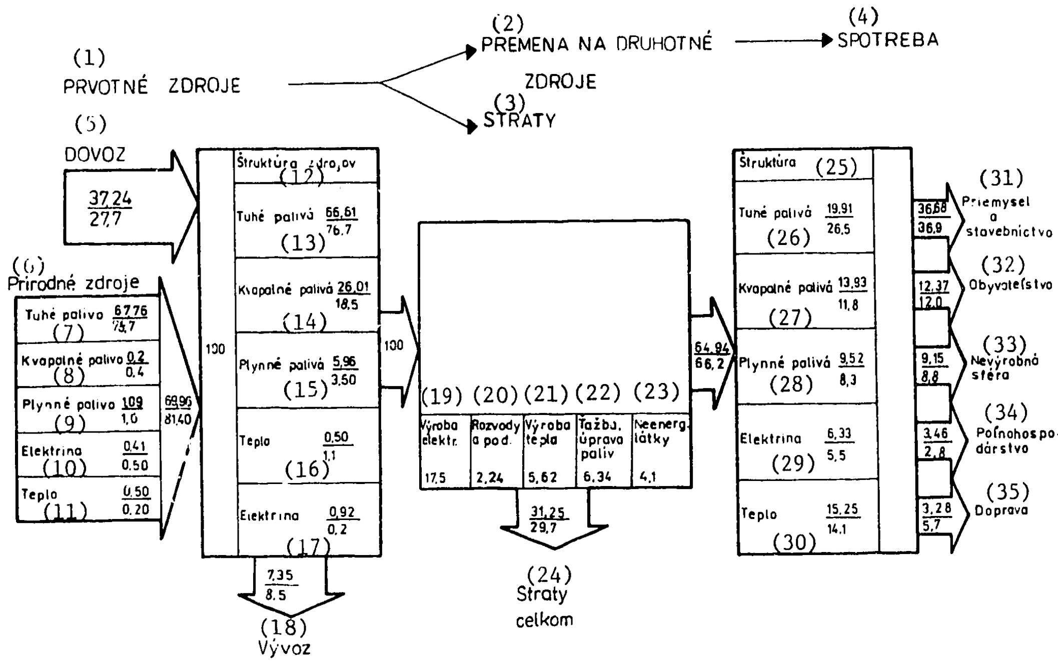

Figure 1. Structure of CSSR Fuel and Energy Balance (Percentage Data For 1970/1977)

Key:

1. Primary Resources
2. Conversion to Secondary Resources
3. Losses
4. Consumption
5. Imports

[Key continued on following page]

6. Natural resources
7. Solid fuels
8. Liquid fuels
9. Gaseous fuels
10. Electricity
11. Heat
12. Resource structure
13. Solid fuels
14. Liquid fuels
15. Gaseous fuels
16. Heat
17. Electricity
18. Exports
19. Production of electricity
20. Distribution, etc.
21. Heat production
22. Fuel mining and processing
23. Nonenergy materials
24. Overall losses
25. Structure
26. Solid fuels
27. Liquid fuels
28. Gaseous fuels
29. Electricity
30. Heat
31. Industry and construction
32. Population
33. Nonproduction sphere
34. Agriculture
35. Transportation

It follows from this diagram that 35 percent of overall primary energy resources are consumed in the production of secondary energy sources which are directly utilized. Of the secondary energy sources (65 percent), industry and construction consume 36.7 percent, transportation 3.2 percent, agriculture 3.5 percent, the nonproduction sphere excluding the population 9.1 percent, and the population 12.5 percent.

Our Production Is Energy Intensive

In connection with issues of the energy balance of our national economy frequent mention is made of the great energy intensiveness of the Czechoslovak economy. Even though this is a declining trend (see citation 8 and Table 11), a comparison with other countries, extrapolating to an internationally comparable volume of gross national product (UN methodology), yields the results presented in Table 12.

Table 11. Domestic Consumption of Primary Energy Resources in Relation to Gross National Product

	1955	1960	1965	1970	1975	1980
1,000 MTSF per Kcs 1 billion of national product	319	285	312	259	224	214

Table 12. Energy Consumption per Unit Volume of Gross National Product

Country	Kilograms Standard Fuel per dollar 1960	Kilograms Standard Fuel per dollar 1975	Index in percent 1975/1960	Expressed Ratio in percent 1960	Expressed Ratio in percent 1975
CSSR	3.56	3.10	87	100	100
East Germany	3.87	2.96	76.4	108.7	95.4
Poland	3.86	2.88	74.6	108.4	92.9
Belgium	2.50	2.59	103.6	76.2	83.5
West Germany	2.19	2.31	105.5	61.5	74.5
Great Britain	2.73	2.39	87.5	76.6	77.0

Even though these are only approximate data, representing various viewpoints, after recalculation on the same basis the energy intensiveness of the Czechoslovak economy comes out higher in comparison with similar countries. Among the principal reasons for the high energy intensiveness of the Czechoslovak economy is, in particular, an inadequate valuation of fuel in the production process, a low level of utilization of capital assets, high material intensiveness, the utilization of obsolete capital assets and energy-using tools, and the inadequate maintenance of all of these. These reasons find expression in a low national economic output per total primary fuel and energy inputs. A reduction in the energy intensiveness of the Czechoslovak national economy is closely connected with its overall economic efficiency.

With this brief description of the balance of energy resources and consumption worldwide and in Czechoslovakia, I have tried to demonstrate:

--the significance and importance of energy management, of the assurance of sufficient resources of energy for the coverage of growing needs for them for the economic development of individual regions throughout the world, as well as to emphasize the seriousness of these problems from a global viewpoint, where they belong among the most pressing problems, along with the preservation of the environment, which mankind must show himself able to solve for his own existence and further development;

--the energy situation here in Czechoslovakia, principally however the lack of primary energy resources on the one hand and the high energy consumption of the Czechoslovak economy on the other.

One may conclude from these realities that the rationalization and conservation of fuels and energy is a vitally important task for the Czechoslovak national economy more than for many other countries. This rationalization must be implemented according to the resolutions of the 15th CPCZ Congress and the decrees from the session of the CPCZ Central Committee Presidium, in such a way as to require from us the establishment of principles for a new management system for the national economy. I will restate this in other words: the resolution of fuel and energy conservation is no mere "faddish element," but a pressing need dictated by objective reality. And we must all set to the task of conserving fuel and energy with this awareness of its significance and importance.

Oil-Refining Industry--Important Component of Fuel and Energy Conservation

From the viewpoint of the oil-refining industry, we must resolve the issue of fuel and energy conservation in a number of directions, in particular:

--the utilization of crude oil and crude-oil distillates in the national economy, and the related issue of oil refining technology, the introduction of cracking, and other, procedures which are being developed in the world in connection with achieving the maximum use from the valuable raw material that is crude oil;

--fuel and energy conservation and reduced losses in our own production processes and in the technical setups which we have already built in our oil refineries;

--the development of new types of products with improved qualitative properties and the resultant use values, which have an increased life expectancy, lower average consumption, or which represent new types of materials, the application of which will lead to energy savings on a nationwide scale;

--a reevaluation of the currently valid quality standards of products from the viewpoint of their use values under a certain application in connection to the energy intensiveness of their procurement;

--a reduction in the average consumption of crude-oil distillates for the production of the basic raw materials of the petrochemical industry.

In view of the breadth of the above-mentioned issues, we will concern ourselves in the remaining parts of the article with the issue of fuel and energy conservation at an existing oil refinery. I want, however, to make some remarks on the issue of oil refining. The Czechoslovak crude-oil industry has not as yet built a cracking process which would assure an increase in the extractability of so-called world products from processed crude oil or improve the quality of produced motor fuels. This situation, in addition to lowered efficiency in the processing and valuation of crude oil, is the cause of reduced factory flexibility in relation to the requirements of the national economy (particularly variations in seasonal fuel consumption). World developments in crude-oil processing are oriented in such a way that crude oil and crude-oil distillates will be used to assure:

--raw materials for the petrochemical industry;

--fuels for the transportation of people and goods;

--fuels for mechanization, including the mechanization of agriculture;

--special requirements, such as lubricants and the like.

Its use as an energy fuel is completely ruled out for the future. Today, refineries for crude-oil processing including the development of adequate technical procedures, refineries for the exclusive production of heating oils (energy fuels), the so-called "no-fuel refinery," are the subject of proposals, studies and designs. (See citations 10 and 11). From this viewpoint, it is quite unambiguous that we must, in the Czechoslovak oil-refining industry, assure very consistently and in the near future the construction of cracking facilities at least to an extent that corresponds to world refinery standards. It is obvious that the construction of cracking facilities to assure the complete refining of crude oil must be coordinated with the development of atomic energy, in terms of freeing up raw material resources, at the same time that both programs are very demanding from an investment point of view.

In resolving the issue of crude-oil refining and motor-fuel production, there is a need for an answer as soon as possible from the crude-oil industry to the frequently asked question of the "dieseling" of the personal automobile, even though answers must also be provided to this question by employees of the automobile industry as well as employees in other areas (environmental preservation, etc.)

These answers will influence the resolution of crude-oil refining for the assurance of individual types of motor fuels, in connection with the assurance of raw materials for petrochemical production.

I want to emphasize particularly the issue of the valid standards of quality for crude-oil products. Many of these valid quality standards for crude-oil products date from a period prior to the beginning of the world energy crisis. They were formulated without taking into consideration such precise demands for the conservation of fuels and energy as are commonplace today. Therefore, in many cases they define certain qualitative parameters in a technically "accurate," more accurately stated would be "acceptable," fashion, but which are from an economic viewpoint, from the viewpoint of fuel and energy conservation, unjustified, or to put it another way, "luxuries." In a comprehensive approach to the solution of fuel and energy conservation, we will have to focus considerable attention on this area, and evaluate very critically certain valid standards of quality and determine their optimal indicators in such a way that the products fully conform in their own qualitative indicators to the demanding requirements of their application, at the same time that demands on energy consumption are minimized during their production.

Slovnaft Has Achieved Good Results in Energy Conservation

The Slovnaft national enterprise is devoting much attention to the conservation of fuels and energy. The employees of the enterprise have comprehended the seriousness and importance of the fuel- and energy-conservation issue, and our workers, technicians, improvers, rationalizers, and comprehensive rationalization brigades are all sharing in its resolution through a creative, initiating approach. We exceeded the planned tasks of comprehensive socialist rationalization throughout the Sixth Five-Year Plan, with the exception of 1976. By 1979, we had fulfilled the planned target for the Sixth Five-Year Plan by conserving 291,000 metric tons of standard fuel. During these 4 years we managed to save 293,000 metric tons of standard fuel. Improvers occupy an important place in the resolution of fuel and energy conservation at our enterprise. In 1979, 33,900 metric tons of standard fuel were conserved through the efforts of the invention and improvement movement. The solution of scientific and technical development tasks in the plan in the fuel and energy conservation division of the enterprise research and development base contributed savings of 11,600 metric tons of standard fuel in 1978 and almost 16,000 Mgmp of standard fuel in 1979. Further fuel and energy savings were achieved by reviewing technical and economic standards and by implementing measures dictated by this review, and by introducing technically justified standards of fuel and energy consumption. Recently, comprehensive technical and economic examinations carried out by the office of the chief technologist in cooperation with other enterprise experts have contributed efficiently to the solution of fuel- and energy-conservation problems. The stabilization of technical procedures has played an important role here, as has increased technical discipline and attention to capital assets. The result has been greater operational reliability, an extension of the useful life of equipment, and its long-term operation according to technical procedures, all of which lead to a reduction in, more accurately to the minimization of fuel and energy consumption. With regard to the processing of raw materials, it is necessary to evaluate as well the development of production losses. In this area as well, Slovnaft has achieved positive results. (See Table 13).

Table 13. Development of Losses at Slovnaft National Enterprise During Sixth Five-Year Plan

	Losses	Incinerated Material at Facility Burners
1979/1976	0.83	0.62

In nationwide competitions for the conservation of fuels and energy, the employees of Slovnaft have since 1976 placed among the first five competitors five times and have won several other high rankings. To support the development of worker initiative at the enterprise in the conservation of fuels and energy, the principle has been implemented at the enterprise of the payment of increased wages for patents, inventions and improvements which contribute to fuel and energy savings. The enterprise management awards special material incentives for solutions and the implementation of tasks from KSR [Comprehensive Socialist Rationalization] programs, and scientific and technical development plans which aid the conservation of fuel and energy. Six KRBs [Comprehensive Rationalization Brigades] work at the enterprise on fuel- and energy-conservation tasks.

Fuel and Energy Conservation Requires Comprehensive, Systematic Approach

The Seventh Five-Year Plan places before us more complex tasks in every sector than we faced in the Sixth Five-Year Plan. In the fuel- and energy-conservation sector, these difficulties are increased by the above-mentioned situation in the balance of fuel and energy supplies and requirements, both worldwide and in our own economy. The highest party and state agencies have included the building and development of a fuel and energy base among the top priority state development programs. In the enterprise sphere as well, the conservation of fuel and energy, or the rationalization of fuel and energy consumption must be placed among the main objectives of the administrative work of enterprise managerial employees. The pressing nature of the long-term need to resolve fuel and energy conservation and the complexity of the task requires us to seek new and, on the basis of current findings and experience, improved work forms, not only at the enterprise level, but with a broader view as well to achieve the greatest possible long-term effect.

The findings and experiences which have been gained in fuel and energy conservation work to date indicate that a significant portion of fuel and energy savings may be gained:

--by the quality management of technical processes, and their long-term operation according to designed, regulated, or optimal parameters;

--quality maintenance of equipment, thereby achieving high operational reliability of the equipment.

These measures make possible 2 to 15 percent savings of fuel and energy depending on the technical condition, technical sophistication, and composition of individual factories. Because a majority of factories and production and energy units were designed and constructed prior to the onset of the global energy crisis, these facilities are not built or designed to such precise energy efficiency specifications, or to minimize fuel and energy consumption. Therefore we must add a third trend to the above-mentioned two directions in fuel and energy conservation and that is the technical and technological modification of what are currently individual procedures and equipment, as well as whole production units and their facilities, their modernization and reconstruction. At a certain stage of the gradual rationalization of fuel and energy consumption, it is precisely this component of the rationalization program that becomes decisive.

The fulfillment of demanding tasks in the area of fuel and energy conservation at the enterprise level (as well as to a broader extent) requires a comprehensive, systematic approach, the elaboration of a complete program of fuel and energy conservation which will not represent a one-time list of measures, but a dynamically functioning system of management and control of the production process from an energy viewpoint. Such a program must include:

--an active, creative, and initiative-taking approach by all managerial employees at all management levels;

--efficient and effective organization, which will assure the achievement of the identified goals;

--instruments for the management and control of the energy economy to determine the efficiency of utilization of energy resources and the determination of when, and how much, energy is used inefficiently, and also to monitor the functioning of the whole energy system;

--the participation of management services, including the use of computer technology;

--the continuous training of enterprise employees, including their motivation;

--the creation of concrete projects for the conservation of fuel and energy, their preparation, comprehensive assurance and implementation, as well as the monitoring of their results and contributions.

Supervisory managerial employees must become personally involved in the solutions to energy conservation problems. They perform an irreplaceable function in the formulation of the concrete objectives which we want to achieve within a definite time period. These objectives must be established rigorously but realistically, and must be based on a thorough analysis of the current situation. Solutions to energy-conservation problems must have a priority position on the list of target programs which occupy the time of enterprise management, as well as party and union organizations. Fuel and energy conservation must become one of the most important goals of supervisory enterprise employees. The priority given to energy conservation must be known to all employees of the enterprise. Supervisory employees must create personally the conditions for the fulfillment of the individual tasks of the program, and supervise the activities of divisions within the enterprise aimed at achieving the outlined goals in energy conservation.

The fuel- and energy-conservation program requires for its implementation a smooth-functioning organization at all levels of management. This organization must assure:

--the formulation of individual tasks, the elaboration of designs for energy conservation;

--the implementation of individual measures, even on a smaller scale, for energy conservation;

--the constant and systematic evaluation of the condition of the energy management of every single production, operational factory and enterprise in relation to the outlined objectives;

--control over the fulfillment at every workplace of its tasks and responsibilities flowing from the energy-conservation program.

For the efficient inspection and administration of the energy management of every production site and of its energy efficiency, we must have a definite method of evaluation which will be relatively simple and able to function objectively, i.e., which will provide the requisite picture of the condition of the "energy level" of the production site. For each production unit and its technical procedures there must be a definition of those technological magnitudes and values which critically influence energy consumption, and the inspection and management of these indicators must be the subject of particular attention by staffers. The need to inspect and administer energy management requires that every production unit, operation, factory, and enterprise work out energy accounting schedules with definite limiting values, and which represent the target condition of energy management. Computer technology may be used very efficiently for these purposes.

Significant energy savings may be obtained at existing facilities through their highly qualified management by service workers along with the occasional use of a process computer. Energy conservation as a rule requires the management of technical procedures and production-site operations at "marginal" parameters, which places newly increased demands on service workers both in terms of magnitude and difficulty. This indisputably important task is performed by excellent measuring and regulational technology, microprocessor or computer technology combined into an online system.

People determine the success of the fuel- and energy-conservation program. Great efforts must be devoted to constant professional training and employee motivation. A very effective motivational element is personal example, the direct participation of supervisory employees in the explanation and clarification of the main objectives of the program and the solutions of its key problems, as well as the periodic evaluation of the position reached in terms of the established goals. Employee training for the service and administration of key technical procedures and apparatus from the energy-conservation viewpoint bears important significance for both new employees and employees with long-term experience. Special preparation is required for selected technical and engineering employees who must deal professionally with fuel- and energy-conservation issues.

It follows from the above-mentioned fuel- and energy-conservation program that its implementation requires a change in the administration methods for fuel and energy conservation at the enterprise level, as well as at higher organizational levels. It certainly must assume an increased degree of importance in the work of managerial employees. There is a pressing need at the enterprise level for the training and engaging of systems engineers in the solutions to fuel and energy conservation issues. Technologists at production units, factories, and enterprises must devote substantially greater efforts to fuel and energy conservation, at the same time that the enterprise technologist must be the most highly qualified energy engineer of the relevant production site and must perform this function in the sense I have mentioned. On the other hand, employees of the energy divisions of the enterprise must get to know in much more detail the technical production procedures from an energy viewpoint, so that they can approach in a qualified manner the creation and assurance of a program of fuel and energy conservation.

In conserving fuel and energy it is necessary basically to solve two diverse tasks:

--to formulate goals, and a fuel and energy conservation program, on the basis of solid knowledge of the technical procedures in production, product quality, an awareness of world development and, and I want to call particular attention to this, a long-term program with more fundamental effects on the existing condition of technical procedures;

--to assure the implementation of the measures adopted in connection with the fuel and energy conservation program and its consistent monitoring. The monitoring and inspecting energy service belongs in this area.

The character of these tasks indicates that their resolution should be assured within an enterprise by various divisions, and that they cannot be assured well only by the division of the head energy expert, especially the first of them.

Where to Search for Fuel and Energy Conservation?

It is possible to state generally that we can achieve fuel and energy conservation in the production process:

--by optimizing operational technical conditions and parameters;

--by modifying equipment and apparatus with the objective of reducing estimated unused capacity;

--by increasing the level of energy (heat) integration among individual procedural loops;

--by integrating exothermal and endothermal reaction processes within the unit;

--by linking the production of steam and electrical energy;

--by modifying product-quality standards where use permits;

--by utilizing new, energy-efficient technologies;

--by adopting new procedural approaches which are less energy intensive.

With regard to the nature of the raw materials processed in a refinery-petrochemical complex, we must conserve fuel and energy in these areas:

--the efficient processing of crude oil to cover national economic needs by minimizing unit consumption of crude-oil materials in the production of petrochemical products and the efficient utilization of all material flows. An increase in the thoroughness of crude oil processing including the limitation and even cessation of the production of heating materials;

--a reduction in all types of raw-materials losses and of materials during the production process;

--increased energy efficiency through conversion of primary types of energy to secondary in enterprise heating plants;

--increasing the energy efficiency of procedures in primary and secondary production, as well as in supplementary production.

The efficient processing of crude oil at existing technical facilities requires the selection of an optimal mix of raw materials for petrochemical production, including the production of extracts and the management of pyrolyses with the maximum feasible pyrolysis schedule. It also requires the efficient utilization of individual material flows, especially secondary ones. It is also essential from the viewpoint of fuel and energy conservation to solve the problem of constructing cracking facilities, or a combination of cracking facilities at the enterprise.

The reduction of production losses represents a significant component of fuel and energy conservation. In addition to production losses at production units, there is the question of losses at facility burners, the utilization of waste gases for technological or energy purposes. Moreover there are losses through reservoir evaporation, losses arising from the mixing up and overdrawing of warehouse materials and in materials handling.

Increasing energy efficiency by converting energy requires the operation of the enterprise power plant at its maximum efficiency for the production of electrical and heat energy in relationship to the energy needs of basic chemical production. This requires the assurance of high heat efficiency of the boiler, along with consistent utilization of the heat from byproducts by means of recuperation, the use of heat from warmed waters and condensates, and the use of the condensates themselves, the utilization of steam energy at the time of its delivery to the enterprise distributors at varying pressure levels by the installation of expansion turbines.

We must decisively provide for an increase in the energy efficiency of procedures:

--by modifying existing procedures and equipment and their combinations;

--through the development of new procedures and equipment.

The modification of existing procedures and equipment basically includes:

--a reduction in the unit consumption of energy for the technical procedure itself (the use of new catalysts to reduce the work heat and the lengthening of working cycles belongs here, as does a reduction in circulational relations, a reduction in reflux relations in distillation columns, the replacement of silica gels with molecular nets in drying procedures with a resultant reduction in regenerational heat, increasing furnace efficiency through the use of the waste heat from combustion products, reducing the consumption of driving steam, the utilization of low-potential heat through the introduction of heat pumps, the elimination of nonessential intermediate storage facilities with the obligatory pumping, cooling, or heating of materials, the utilization of waste heat from individual material flows, reducing systemic pressure losses, etc. We are including here as well a reduction in the quality of products whose cleaning requires consumption of large amounts of energy, even while that cleanliness is not essential in terms of the usage of the product);

--the utilization of more efficient equipment (including improved ignition burners for furnaces and boilers, new types of more efficient pumps and electric motors, regulating valves, quality equipment insulation, the cleaning of heat-exchanging equipment, etc.);

--the utilization of waste products by burning them to produce energy;

--the application of modern administrative computer/microprocessor systems for the control and management of procedures, and, in some cases, selected parts of equipment with the objective of managing and stabilizing a procedure according to given parameters.

It is evident from the character of these tasks that their resolution demands a highly qualified, technical and engineering, and in particular chemical-engineering approach with the possibility of using computer technology. It also requires the very efficient and effective cooperation of employees and technologists both in the identification of problems and their solutions, as well as in the implementation of measures. It requires the active participation of employees of the enterprise scientific-technical base as well as from nonenterprise scientific research and professional workplaces.

Conclusion

The achievement of significant results in the conservation of fuel and energy also depends on the influence of certain external circumstances. I will mention two of these which seem particularly important at this time.

First, there is managerial and coordinational work at a responsible level. I have in mind direct assistance in the assurance of important projects for the rationalization of fuel and energy consumption and coordination in the implementation of complicated comprehensive measures of the state rationalization program, which at the level of the administrative agency should not be merely the sum of the measures implemented at the enterprise level, but a set of interenterprise and supraenterprise projects coordinated in such a way that their implementation can cause a synergetic effect, with the administrative agency as a separate unit.

Second, there is the assistance of the engineering sector and other sectors during the implementation stage of our measures. This is a question of assuring production and assembly facilities and certain priorities, such as the development of highly efficient measures in the crude-oil-refining industry which will contribute to energy conservation. Moreover, we are of the opinion that our engineering industry should also assure its own production of equipment which it could then apply on a wider scale to reduce the consumption of fuel and energy. In view of the overall importance of fuel and energy conservation, I would recommend that the possibility be created for the purchase abroad of certain equipment needed for the rapid implementation of important rationalization measures, when necessary in nonsocialist countries.

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Regulation Effects in Oil Refining, Conservation

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[Article by Eng Dr Mirko Dohnal, Candidate for Doctor of Science, Chemical Machinery Department, Engineering Faculty, Technical Institute, Brno: "Regulation of Oil Refining Technology and Energy Conservation"]

[Text] The situation on the world market is such that the prices of primary raw materials are growing very rapidly. This is forcing large inroads both in the design of new equipment and in improvements in existing technology. Leading foreign firms have already been studying for almost 10 years in a systematic and integrated fashion possibilities for lowering the consumption of ever more expensive energy. Because the period of time devoted to these conservation programs has already been sufficiently long, it is possible to evaluate their results.

Regarding automation, the achieved results may be divided as follows (the cited percentages represent a reduction of overall energy currently consumed at the refinery):

--reduced energy consumption directly attributable to automation;

--installation of a control computer (distributed network, programmable regulators, etc.), 0.3-0.8 percent;

--regulation of furnace combustion (ignition), 0.3-0.4 percent;

--reduced energy consumption partly attributable to regulation which could not be realized without adequate regulation;

--integration of heat exchanges among technologies, and installation of additional exchangers within the framework of a single technology, 2-3 percent;

--intensification of unit operations (besides furnace), 3 percent.

In addition, it is known that about 20 percent of the overall amount of conserved energy is obtained with the aid of system-optimizing studies. Specifications often appear within these studies for the maintaining of relationships between parameters which would be unthinkable without state-of-the-art regulational technology. So even energy consumed in this way has a certain connection with regulation. It is, then, evident that within the framework of the chemical industry, regulation shares in about 0.6 to 1.2 percent of total conserved energy in an enterprise and indirectly in about 10 percent of the total.

It follows from the foregoing that if only regulation were employed to the maximum extent possible at our chemical factories to reduce energy consumption, then the requirements for reduced consumption of primary energy resources would be covered in this manner only over many years.

The connection between the optimizing studies, their implementation and the introduction of new regulation technology is clear. There are equally clear connections between innovation and regulational technology, and in other areas as well. Thus it is understandable that the use of new regulational technology can contribute a maximum effect in those instances where regulation will be considered as only one of the means for reducing energy consumption. It is, therefore, necessary to mention at least the basic trends in energy conservation.

In an article discussing only a specific aspect (regulation) of an integrated conservation program at crude oil and chemical factories, it is impossible to consider the remaining possibilities. Here, therefore, a breakdown of these methods (approaches) will be presented only in schematic form:

--theoretical methods;
--systems analysis;
--optimizing technologies;
--vector optimalization;
--synthesis;
--heat-exchanger-network synthesis;
--whole technologies synthesis;
--operational research;
--decisionmaking and use theory;
--statistical simulation;
--thermodynamic analysis;
--calculations of properties of materials;
--data bases;
--enthalpic balances of apparatus and procedures;
--exergetic balances of apparatus and procedures;
--calculations for separate apparatus and operations;
--furnaces;
--diffusion operations;
--distillation;
--evaporators;
--heat exchangers;
--pumps;
--compressors;
--chemical reactors;
--engineering inroads;
--regulation;
--regulation of energy intensive equipment;
--ASRTP [Automated System of Technological Process Control];
--energy generation;
--steam production;
--cogeneration of steam and electricity;
--steam distribution;
--construction of equipment;

--influence of construction design on energy consumption;
--equipment to utilize waste heat;
--maintenance;
--reservoirs;
--maintenance organizations;
--maintenance;
--insulation;
--steam distributors;
--apparatus;
--equipment operation;
--operational smoothness;
--adequate raw materials;
--proper equipment loads;
--organization;
--organization of energy conservation;
--conservation through proper organization;
--operational management.

The information contained in citation 1 is interesting for further analysis. Forty-one percent of total energy consumed is consumed for industrial purposes. This includes:

--16.7 percent to produce steam;

--11.5 percent for direct heating;

--7.9 percent to drive machinery.

Current Capacities of Regulational Technology

In the literature there exists literally a huge amount of data on the subject of what regulational technology may be reliably used in industry and what will be available in 2 or 3 years. There are a number of useful monographs such as citations 2 and 3. This information, however, becomes obsolete very rapidly, so it is necessary to consult literature from specific firms, such as citations 4 through 6.

It is not, however, our objective to analyze these issues from the standpoint of regulation, but from the viewpoint of chemical technology. Here, then, it will be necessary to resolve mainly such questions as, for example, the justification for introducing expensive regulational technology, and the contributions this technology makes (citation 7).

The economic leadership must justify an investment in the installation of regulational technology. This is a very significant issue, because it is here that the correctness of the investment is judged. But from practice it is well known that it is not quite so simple to compile the necessary data.

The issue of the introduction of regulational technology is, at first glance, a simple matter: formulation of a request; contract; installation; startup. At this point, however, numerous interests and requirements come into conflict citations 8 and 9). It suffices to be aware of the number of phases which a proposed regulating system or regulating technology must pass through, if optimal regulation is to be achieved (citation 10).

Control computers are already more or less a common component of chemical technology equipment. Today there is already a body of experience on developing and implementing a project (citation 11). Given the rising cost of energy, however, when the goals which are to be achieved are being defined, it is essential to take into account the increased importance of energy consumption. The problem lies in the fact that energy is only one goal which is to be achieved through the introduction of a control computer.

It is possible to name a whole series of similarly important goals, for instance:

--increased safety;

--reduced raw materials consumption;

--reduced numbers of employees.

Here we confront the problems related to vector optimalization.

The introduction of control technology is being played out at a time of sharp growth of microelectronics and the additional development of traditional regulational and measurement technology. This development is being monitored with some difficulty by specialists in the field of regulation (citations 12 and 10), or, for example, citations 12 and 13. Their colleagues (the designers and technologists) must adapt themselves to this during the implementation phase. It is sufficient for this, however, to have a basic conception of these technologies (citation 14).

Microcomputers have already penetrated the production of control computers, programmable calculators, and measurement technology. Their introduction in these fields has the same advantages as in their other applications (citations 12 to 14). There is no need, therefore, to discuss them here. It is sufficient to mention a single example: the payback period for the direct numerical control of distillation of aromates by means of chromatography is less than 1 year (citation 15). At the same time, from a regulational point of view this is a very complex problem both mathematically (the analysis of a chemical and engineering process) and in terms of hardware.

So far we have concerned ourselves with the general outlines of modern regulational techniques and their influence on modern regulational technologies. There exist, however, certain regulational problems which are directly related to the conservation issue (citation 16 and 17). Information which has already been published concerning the possibilities for saving energy through regulation has been either directly connected with regulational hardware (e.g., citation 18), or discusses various (chemical engineering, technological) influences of regulation on energy consumption. Concrete economic data on how much energy may be saved in this manner is especially useful for our industry.

Between 1960 and 1970 regulational costs represented about 3 to 5 percent of total investment costs. At present it is sensible economically to estimate 10 percent. This increase may be justified by the following advantages:

--safety;

--frequent exchange of processed raw materials;

--time (deviation from assumed values);

--changes in raw materials for commercial or economic reasons (the constant processing of raw materials other than those for which the technology was designed);

--rigorous requirements for product characteristics (sharper market competition);

--more complex technology.

All of the above are directly related to the saving of energy. Safety issues may force maintenance crews to shut down and start up equipment relatively frequently. This means that large parts of a given machine cool down and again heat up, which is undesirable from an energy viewpoint. Or equipment may operate far from conditions which are dangerous, but in the vicinity of which operation is optimal.

And if, due to insufficient regulation it happens that a product must be processed twice (e.g., due to excessive impurities) then this can mean that energy consumption even doubles.

Traditional unit operations such as heat exchangers, distillation towers, etc., are regulated by a method which has proven itself from the time when it was possible to use what are today considered classical analog regulators. This means that in this area there already exists a tradition several decades long. The outfitting of apparatus with gauges and the designing of regulational cycles is, then, a routine occurrence in 90 percent of all cases.

The problem, however, lies in the fact that this simple rule regarding the establishment of regulational guidelines for the above-mentioned unit operations were developed under different economic conditions. The change in the price of raw materials and energy has rendered the accumulated experience invalid. This does not mean, however, that today it is impossible to formulate simple rules for the design of regulational cycles. It is possible. As an example, let me point out citation 20. The recommended changes do not concern regulational techniques already in use. It is possible to save significant amounts of energy simply by changing the position of regulation locations. The example noted (citation 20) of a simple modification of a regulational system for depropanization meant a gain of about $180,000 per year on energy. This meant that the payback period was substantially shorter than a month.

Foreign practices display the easily comprehensible attempt to utilize heat even outside of its own technologies. This means, however, that when we must shut down the technology from which heat is taken for another, then it is necessary either to shut down both systems or to employ a secondary source of heat. It is necessary to realize that such connections must inevitably make more difficult the regulation proposals for whole technological groups. The dynamic behavior of technologies combined in this manner will pose more difficulties from a regulatory viewpoint. A serious analysis of these issues is not feasible given the current level of theoretical knowledge. Mathematical models of the actual technologies do not exist, so it is possible to implement these concepts only in terms of very simple examples.

Energy consumption is distributed very unevenly within the framework of a single technology. It is possible to make the same statement regarding a whole chemical factory. Various technologies consume very different amounts of energy. Therefore it is appropriate to focus attention on those components which are most important from an energy viewpoint. This makes possible distributed regulation (citation 21).

Citation 22 contains a highly instructive sketch of current trends in the use of regulation for the saving of energy. Results are aggregated here which were achieved in this area in the past 3 years. This reference contains not only information regarding possible energy savings through the appropriate introduction of contemporary regulational technology. It is also possible to find here reliable, serious sources which discuss recent hardware and software developments in the area of regulation.

Measurement is the basis of all regulation. To date, some quantities in the chemical industry have not been measured at all. There was no reason to do so, as long as energy was cheap. A typical example is the distribution of steam. In some of our enterprises, it is still not clear how much steam is used by individual technologies. This means that it is impossible to monitor the energy consumption for these technologies. There are difficulties with such measurements, especially in cases of aggressive materials at high temperatures and pressures. But current techniques have already dealt with these problems (citation 22).

Moreover, it is not necessary to measure everything. A proven methodology exists today for calculating certain quantities on the basis of the laws of conservation of matter and energy. The field which concerns itself with this problem, i.e., energy management, finds great application in instances where we are attempting to introduce a control computer for the automation of chemical processes. A knowledge of material flows and of the energy in each flow over time is basic information.

Accounting is the lowest form of systems analysis. At the same time it requires a consistent analysis of a process. Moreover, the whole approach is iterative, because at the beginning of the study it is not possible to determine whether the input data is sufficient. This means, then, that the accounting may last several months or more than a year.

We can also form a rough conception of steam distribution by using technical quantities at the consumption end (e.g., temperatures in digesters) to compute the amounts of delivered steam. This enables us to obtain the necessary foundations relatively quickly, even though the accuracy will not be more than 20 percent.

So far the information presented has related only to the ways that regulation saves energy. But regulation itself consumes some energy. If a regulation valve is to regulate a flow, then it must change the pressure loss in the tube. Previously it was common to set the valve so that it more or less functioned permanently as a throttle valve. This means that an important part of the input of, for instance, pumps is permanently dissipated (citation 23). Contemporary construction of both valves and regulational components makes possible a minimizing of these energy losses which, given a poorly designed regulation cycle, can be quite large (citation 23).

Regulation of Technology Components Important From Energy Standpoint

In this section we will discuss only three important problems from the standpoint of energy consumption and regulation. Information from the literature shows that there exist two types of apparatus for which regulation can achieve significant savings. These are furnaces and distillation facilities.

A number of additional possibilities exist for saving energy at a facility level through the application of regulation. In these cases, however, the problems resemble to a certain degree those of either furnaces or distillation facilities, meaning that the facility type is not significant.

The system-regulation problem of extraordinary significance for energy is the production, distribution, and consumption of steam. A modern complex for the refining of crude oil requires very complicated steam management. Certain technologies both produce and consume steam, others only produce it. This means that complicated connections exist between specific technologies and boilers.

The fact that it is also possible to produce electric current further complicates the whole situation. This current may then be consumed within the enterprise or delivered to the public network.

It is also important from a regulational point of view that the introduction of regulational technology be preceded by a preliminary phase in which an optimizing study is produced, or in which the facility is at least thoroughly analyzed from a chemical-engineering standpoint. A specific measurement and regulational system may then be proposed on the basis of these studies.

Typical additions are:

--the introduction of a control computer;

--forward regulation;

--the introduction of chromatographs (or other measurement by concentrations);

--optimal regulation;

--mini/microcomputers (distributed network);

--traditional analog regulators.

It is clear that there is a very wide spectrum of regulational techniques used to save energy. It is even possible to save energy with classical regulational technology which has been in use for 20 years and more. On the other hand, currently systems such as optimal regulation are appearing. Here the problem is resolved not only by the introduction of modern regulational hardware, but also with the maximum utilization of theory. It is no longer true that optimization is of interest only for academic study. In the past 10 years industrial practice has overcome the obstacles to the use of optimizing algorithms. These are:

--the impossibility of compiling a sufficiently precise mathematical description of equipment;

--difficulties in the choice of an implementing function;

--lack of knowledge of the constants necessary for enumerating the values of the implementing function.

It is true that the optimizing studies began to have practical sense at the time when appropriate regulational techniques appeared. Only these techniques make possible the implementation of rigorous regulational algorithms which may truly contribute in a significant way to reduced energy consumption.

It is impossible within the framework of one article to analyze in detail the concrete technical possibilities for the regulation of specific equipment. For this reason emphasis is placed here on the economic side. Information which has been accumulated about several concrete projects makes it possible to estimate the economic consequences of specific interventions of a regulatory nature on operational economics.

Experience indicates that the introduction of a control computer can save 10 to 20 percent of the consumption of a distillation column, and 1 to 3 percent of that of a furnace. The introduction of a management information system can save about 0.5 to 2 percent of total energy consumption. From this rough estimate of relative savings it is possible to determine very simply the absolute energy savings for a particular enterprise. Further considerations, however, require a knowledge of the price of the investments needed to achieve these results. Information of this type is, however, very inconsistent, and therefore very difficult to combine into some kind of abbreviated form.

Distillation Columns

The results of a very broad-based study have been published in citations 17 and 24. A total of 438 distillation columns were analyzed. Fifty-six of these were eliminated from further analysis, because they were already sufficiently outfitted with regulational and measurement technology. Some were already equipped with a control computer. These columns were divided, according to the capacities of the digesters, into five groups. Each group was then analyzed from the standpoint of possibilities for energy conservation.

The conclusion was such that it is necessary to focus on columns with digester capacity of at least 20 million kilojoules per hour and larger. The average payback time for investments (purchase of regulational hardware and software) was 7.8 months, the maximum payback period 2 years.

On the basis of these studies, work was initiated on 40 columns which had been chosen for the implementation of optimizing techniques or the installation of a control computer.

The columns were divided into groups according to the payback period of the investment. Economic calculations were based on 1976 prices. Investment in a control system (computer, chromatograph, etc.) was assumed to be $50,000 per column. Only energy savings were considered as gains. No other contributions were evaluated economically.

The towers were divided into groups according to the investment payback period and furthermore as to period:

--less than 3 months;

--3 to 6 months;

--6 to 12 months;

--12 to 24 months.

The group with a payback period of 3 to 6 months is presented as an example. The average payback period was 4.2 months. The number of columns in this group amounted to 36, out of the original number of 382 columns.

An additional example is provided by information contained in citation 19. If a distillation column functions according to an average reverse pressure which is 1.1 times the minimal average of the reverse pressure, the column digester consumes 50 million kilojoules per hour. If there is inappropriate regulation it is essential that 10 percent more energy be consumed in the digester, which results in a yearly loss of about $200,000. This money can be saved through the installation of regulational equipment costing $50,000. This implies that this regulational equipment will pay for itself in about 3 months.

Recommendations are contained in citation 25 as to how to modify an existing regulational and measurement system of a column so as to save energy. The conclusions are presented not only qualitatively, but also quantitatively. The amount of savings can thus be established. These results are accurate to within about 25 percent.

The decisionmaking concerning the introduction of new regulational technology may be appropriately aided by decision trees (citation 26). The decisionmaking tree makes possible a systematic judgment of the risk which can occur during project implementation. It can serve as a foundation for the economic leadership.

The information that an optimally regulated distillation column (or group of columns) may save $1,000 to $2,000 per day can serve as a quick orientation point. Energy savings form only a portion of these savings.

If we are dividing two products, the concentration is determined by the admixture (i.e., of the second product) of the product price. An operator has a tendency to maintain too much product purity. There is a lesser risk that under certain conditions the consumer's specifications for product purity will not be upheld. However, this also leads to significant increases in energy-consumption requirements, even in the event that a product is stored in a container with high capacity. This capacity would compensate for the time alterations in product concentration.

To produce a product 1 percent purer than specifications means to expend more energy than it is possible to save by producing the same amount of product 1 percent below the specified purity (citation 27). A container, then, makes it possible to maintain purity standards, it does not solve, however, the problem of energy conservation. This may be resolved only by introducing such regulational equipment as will make possible truly reliable adherence to purity requirements.

If we have an appropriate model of the dynamic behavior of distillation columns, it is possible to make use of forward regulation (citation 28), which makes it possible to accommodate a predetermined requirement for the maintenance of product concentration. In addition, the yield must be increased. But this often means appropriate hardware (citation 29).

Furnaces

The problem of furnaces is the key issue within the framework of energy conservation. Furnace regulation presents great possibilities in this regard. In comparison with distillation columns, however, it is possible to determine the fundamental problem which the regulation must resolve. Otherwise, it will not be successful. This is the issue of excess air and the related problem of measuring concentrations.

Combustion is one of the main sources of heat for a number of chemical engineering operations (drying, distillation, etc.). It is an operation sensitive to changes in the combustibility of fuels, the humidity of the air, the condition of the burner, and to a number of other factors. In addition, it is necessary to adapt a proposed measurement and regulational system to a specific type of furnace.

Most industrial boilers operate with about 20 percent excess air. If fuel characteristics do not change and the feed is constant, then it is at times possible to obtain reliable operation even with 10 percent excess air. On the other hand, there are furnaces (for instance, certain rotating furnaces) where 80 percent excess air is required (citation 31).

All that has been mentioned demonstrates that a system of measurement and regulation for these extraordinarily important energy facilities is not simple, and that digester will differ from digester, and furnace from furnace. The regulation of such equipment has already been the subject of systematic study for more than 50 years. Regulation based on oxygen concentration is relatively recent in comparison with this whole period. Reliable analytical techniques for measuring oxygen concentration, and that of other gases, has been at our disposal only quite recently.

The introduction of this technique, however, enabled us to reduce fuel consumption 3 percent, which meant a payback period of 4.2 months for a boiler with a capacity of 35,000 kilograms of steam per hour and given an investment of $75,000 in regulation. The following information is very useful for practical estimates of the economic contributions of appropriate furnace regulation:

For boilers producing 50,000 kilograms of steam per hour and more, and with 5 to 6 percent excess oxygen, a reduction of 1 percent in the excess oxygen results in about a 1 percent increase in efficiency (citation 30). When excess oxygen reaches the 3 to 4 percent range, further reductions result in increases in efficiency of only half as much. However, most industrial facilities operate under such conditions that it is possible to assume that a full 1 percent increase in furnace efficiency will be achieved if we reduce the excess oxygen by 1 percent.

From this information it is possible to calculate very simply the savings for large boilers in a chemical factory if it is possible, by means of appropriate analytical techniques, to increase efficiency by 3 percent, at the same time that it is not solely a question of economy. Improved fuel utilization also has a positive effect on the ecology (citation 30).

Interesting data exists concerning the economic aspects of the measurement of concentrations during combustion. Operational reliability and the related minimum demands for maintenance and investment payback period are decisive concerning the economic effectiveness of these measuring techniques and the regulational cycles based on them. The maintenance issue is a technical question which production resolves. The payback period must, however, be studied in connection with the concrete conditions of a chemical factory.

In citation 32, results are presented of an extensive study related to payback periods. The payback period is presented for various sizes of steam generators, and for two variants of measurement and regulational system for each generator. Variant I required investment outlays of $125,000. Variant II, in which additions were made to an existing system, required an outlay of $100,000.

Steam Generator Capacity (1,000 kilograms steam/hour)	Payback Period (Years) Alternative I	Alternative II
91	2.44	1.96
136	1.63	1.31
180	1.22	0.98
227	0.98	0.78

The requirements placed on the measurement of concentrations during the combustion process are demanding. The combustion products pass through the furnace very quickly (in about 3 seconds) (citation 30). This means that they do not accumulate in the furnace. The furnace thus becomes a piece of equipment which must be mastered in a different way than has been the custom in chemistry. This has, as a further consequence, a requirement of minimizing the delay caused by sampling for analysis, or by attempts at the joint measurement of concentrations (citation 33).

The problem of burning waste products is basically the same as the burning of common fuels. The same principles apply. In addition, however, it is necessary to devote increased attention to the fact that the fuel quality will decline much more. At times it will be necessary to burn various fuels and to shift during operations from one fuel to another. This makes regulational and measurement technology all the more important (citation 34).

Pressure to increase the efficient utilization of energy has also forced the use of improved measurement techniques on pressure boilers, where their use had not previously been considered. Today it is profitable to install them on boilers with less than 250 million kilojoules of capacity. In citation 35, there is an interesting list of firms with concise characteristics of their products and representative prices.

The problem of combustion is important not only for the crude-oil industry, but also for the energy sector, the chemical industry generally, and for a number of significant areas such as glass manufacturing, etc. It is, therefore, clear that there exist on the market an extensive assortment of measurement instruments. Thus it is not difficult to compile a list of company literature. Citations 36 to 40 may be noted as examples.

By the same token, modern regulational technology has made it possible to use boilers in boiler rooms at a level of steam consumption that optimizes their operational efficiency. Thorough measuring of boilers makes it possible to determine the rate of consumption at which a particular boiler operates most efficiently. Then it is possible to use this information in order to fire them up or shut them down, or to reduce their capacity so as to minimize their fuel consumption per unit of steam produced. The utilization of these possibilities has brought a decline in fuel use of almost 10 percent.

This forces us to consider not only the regulation of boilers, but also steam consumption. This is, however, an extensive systemic issue, which I will consider in the final section.

Steam Production

Steam is one of the basic energy sources in a chemical factory. It is required for the heating of process flows, it can be used to power compressors, it is necessary for technical reasons. It is produced both in washing boilers, where fuel is burned, and by the use of waste heat from exothermic reactions of individual technologies.

Great difficulties are appearing in the economical use of steam. Steam is produced in modern boilers at relatively high pressures. Its reduction to lower pressures may take place in such a way that the steam is only choked off. This is clearly uneconomical. Reducing the pressure of steam is normally used:

--to produce electricity;

--to power equipment (compressors, etc.);

--to heat.

All of these activities are tied together, because they depend on the operation of technology and the operation of the technologies in a modern, integrated factory are mutually interrelated. To date, a system to regulate the use of steam was organized in the best of instances as in Figure 1. It is clear that there was never any interaction between individual technologies. It was therefore impossible to predict heating plant operation beforehand.

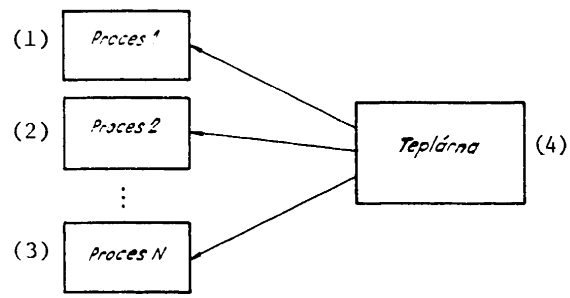

Figure 1.

Key:
1. Process 1
2. Process 2
3. Process N
4. Heat Plant

A modern boiler must react to about 10 percent changes in per-minute performance rates during production. In practice, however, there may be 20 percent changes in per-minute steam consumption (citation 41). So that these rapid changes may be fully covered, an operational boiler is functioning at a level several percentage points above the necessary output. The reaction of the steam distribution network is somewhat more rapid than the normal changes in consumption requirements of the equipment. It is then possible to provide for increases in steam consumption requirements by closing the valve through which the steam blows off into the atmosphere (in this worst-case condition, there is a loss of the condensate or, under better conditions, its entrapment in condensation vessels) and it is then possible to maintain the required steam pressure even given increased steam consumption. If it becomes possible to provide for timely and sufficiently precise estimates of steam consumption by means of some information system such as ASRTP, then it will no longer be necessary to expend energy on the production of unneeded steam (see Figure 2).

Current regulation offers an additional possibility, namely the flexible utilization of steam for both current technological purposes and to produce electricity. Chemical factories can not only cover their consumption of electrical energy, but also contribute to the public network. But even this requires a very well-designed regulatory system (see Figure 3).

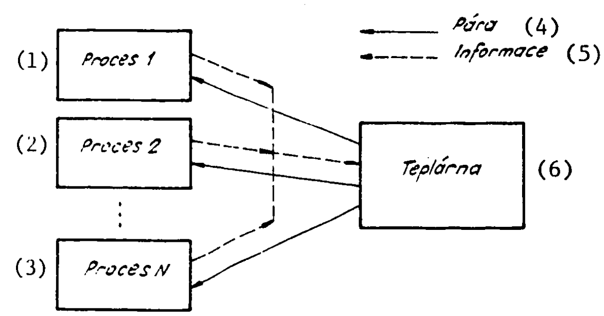

Figure 2.

Key:

1. Process 1
2. Process 2
3. Process N
4. Steam
5. Information
6. Heat Plant

The economic consequences of improved steam management may be estimated at several percent of the total energy consumption of the factory. It is possible to estimate the payback period only with difficulty. It depends on the condition in which the chemical factory is found at the moment when discussions begin concerning the installation of new regulational technology to reduce energy consumption.

The payback period is considered an appropriate quantity for determining where to invest money. A period of 5 years should be acceptable for most factories. The principal influence on this period is increases in the price of steam. Citation 42 contains the costs of steam at various pressures.

At present, steam management is receiving only minimal attention. There is no lack of cases in which there is no knowledge whatever of the steam consumption of individual technologies. The system for measuring steam consumption is in such a condition that it is not possible to assure the required quantities. Given this situation it is possible to achieve a reduction in energy demands for steam production of 20 percent of overall energy consumption.

Generally used programming systems for accounting exist. These systems may be used to calculate material and enthalpic balances in cases where some data is known and some may be estimated, at the same time that it is possible to consider the accuracy of the measured quantities according to various standards.

These universal systems have the advantage of being highly generalized so that it is possible to resolve with their assistance such problems as the relationship between the steam network and technologies, etc., which, on the other hand, require a thorough analysis. It is, therefore, possible to use a specialized system as well, one designed not only to compute the steam balance, as in citation 43. For different steam consumers it is necessary to specify information that is common from an engineering point of view. The same is true of steam sources. The program itself will determine through iterative calculations steam flows in the branches and its enthalpy.

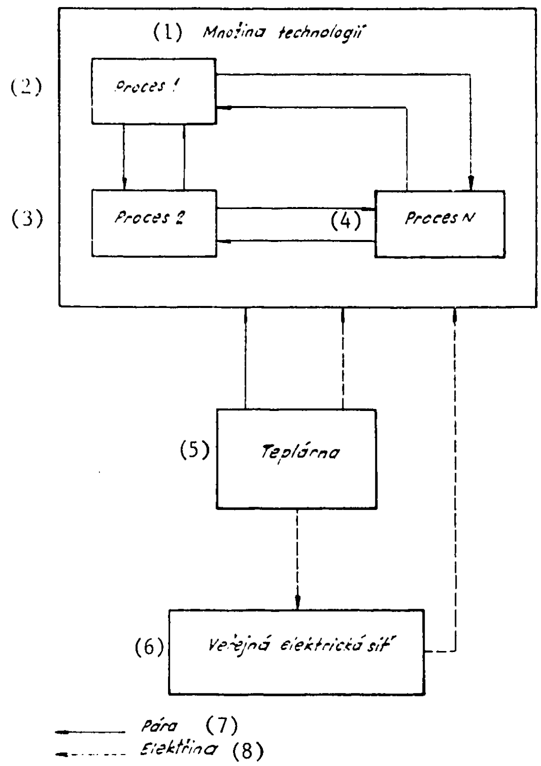

Figure 3.

Key:

1. Numerous technologies
2. Process 1
3. Process 2
4. Process N
5. Heat Plant
6. Public electrical network
7. Steam
8. Electricity

Conclusion

Regulation represents one of the most efficient means for reducing energy consumption in chemical production. The utilization of these possibilities, however, presumes a very thorough chemical engineering analysis. Under no circumstances may specialists in the field of regulation be able to get by with only a superficial knowledge of regulational technology.

State-of-the-art regulational technology is appropriate for the needs of energy conservation. It enables an integrative resolution of this and thereby the achievement of the maximum possible savings. But traditional regulational technology is also usable.

The purpose of this article has been to present as concisely as possible the connections between concrete technical activities and their economic consequences. Such information could be used in estimating energy savings and thereby payback periods. For such calculations, it is necessary to follow publication dates, because all dollar figures change very rapidly. Recalculation is not that simple. If we were to use the inflation coefficients which are published in professional literature (for instance, in CHEMICAL ENGINEERING, USA) we would arrive at improper conclusions. The price of energy is increasing much faster than the prices of computational, regulational, and measurement technology. It is therefore not possible to depend too much on data expressed in financial units. Most of the information is, however, expressed for the most part in financial terms. Data concerning direct savings of amounts of fuel are harder to come by.

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